(12) UK Patent Application (19) GB (11) 2 182 703 (13) A

(43) Application published 20 May 1987

(21) Application No 8623495

(22) Date of filing 30 Sep 1986

(30) Priority data
(31) 8523996 (32) 30 Sep 1985 (33) GB
8618361 28 Jul 1986

(71) Applicant
George William Hunter,
25 Hillhead Park, Hillhead, Brixham, Devon TQ5 0HG

(72) Inventor
George William Hunter

(74) Agent and/or Address for Service
Wynne-Jones Laine & James,
22 Rodney Road, Cheltenham, Glos. GL50 1JJ

(51) INT CL⁴
B32B 3/00 // 15/01

(52) Domestic classification (Edition I):
E1K 21
B3A 124 26 78A
U1S 1465 1577 1591 1673 1676 B3A E1K

(56) Documents cited
None

(58) Field of search
E1K
E1D
B3A
Selected US specifications from IPC sub-classes E04C
B32B

(54) Improvements relating to structural sandwich sheet material comprising two face sheets and two core sheets

(57) A strutural sheet material is of sandwich construction. A basic form has two face sheets (1, 2 Fig. 1); (17, 18 Fig. 8) between which are two core sheets 4, 5; (9, 10; 13, 14; 16; Figs. 5–8) formed with dimples (7, 8; 11, 12 Figs. 3 and 5) from initially flat sheeting. These core sheets are mutually attached with the dimples intermeshing, and they may be spaced from one another or in contact. Multi-ply plates can be constructed from layers of such material, adjacent plies sharing a common face sheet or having it omitted altogether. Reinforcements (15, 19, 36, 37 Figs. 7, 8, 16 and 17) can be incorporated at the edge or anywhere within the periphery. In one form, a reinforcing plate (36, 37 Figs. 16 and 17) is apertured to receive the dimples of opposed core sheets and be secured between them without affecting the face sheets. The reinforcements can be extended (38, 39 Figs. 18 and 20) beyond the edges to provide means for connecting to other structural members.

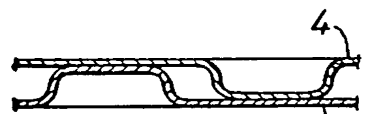

FIG. 2.

GB 2 182 703 A

The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

30 SEPT 86

2182703

1/6

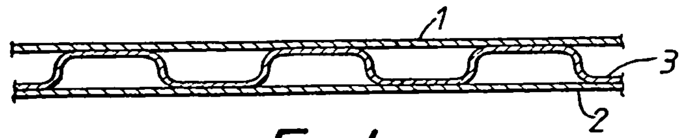

FIG.1.

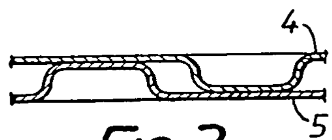

FIG.2.

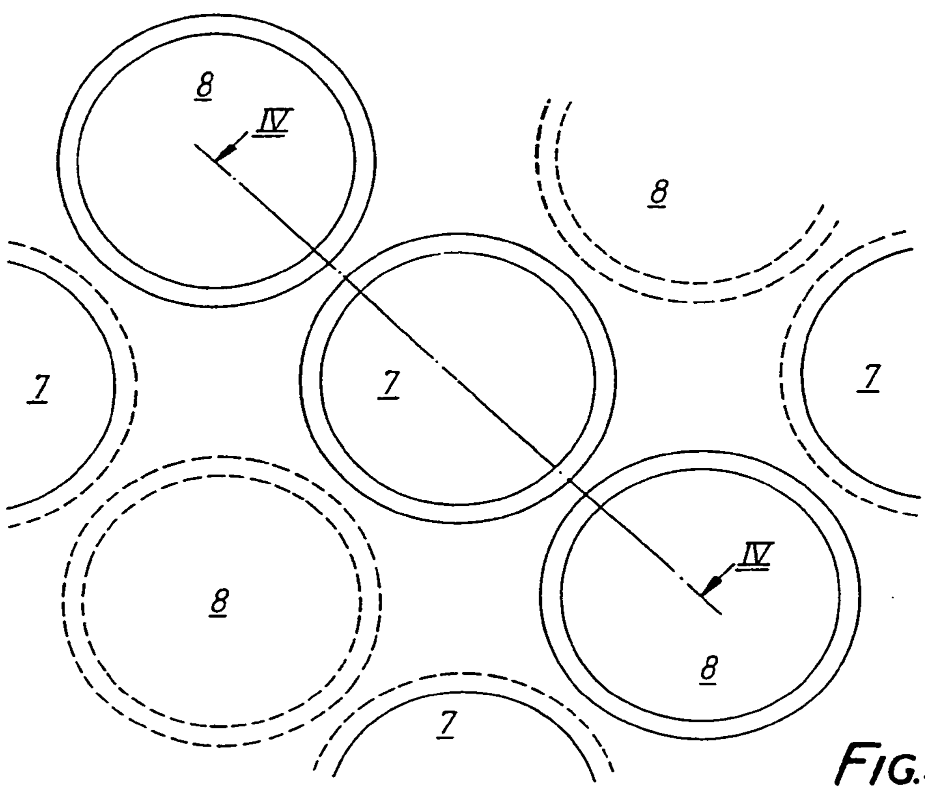

FIG.3.

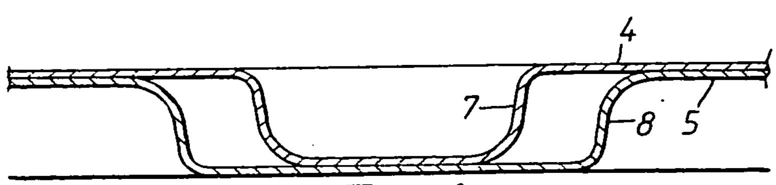

FIG.4.

30 SEPT86

2182703

2/6

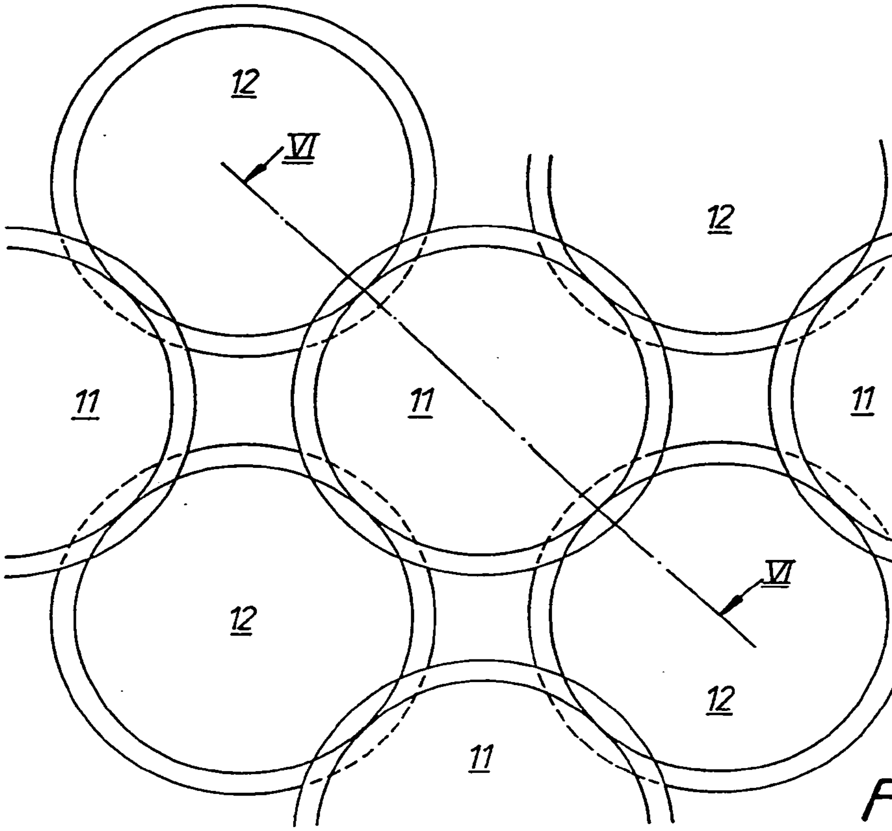

FIG. 5.

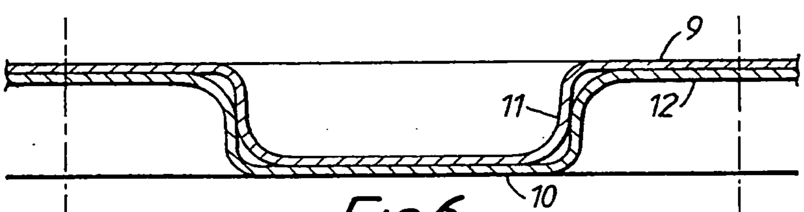

FIG. 6.

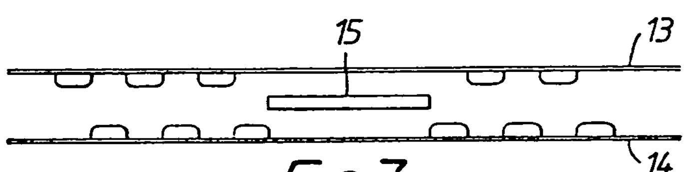

FIG. 7.

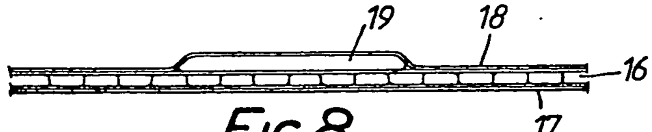

FIG. 8.

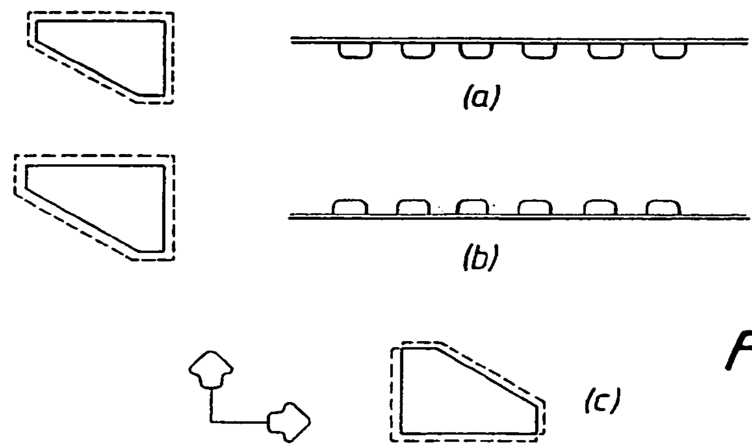

FIG. 9.

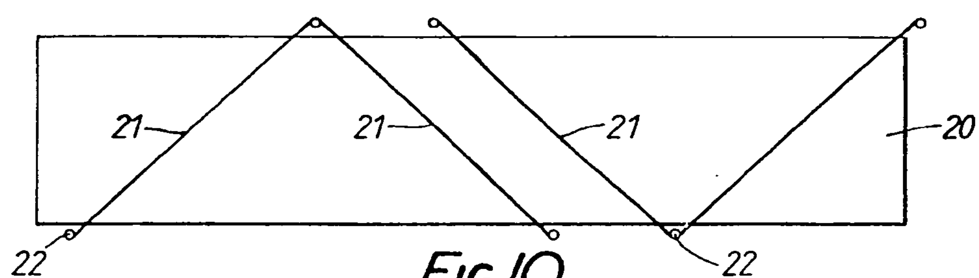

FIG. 10.

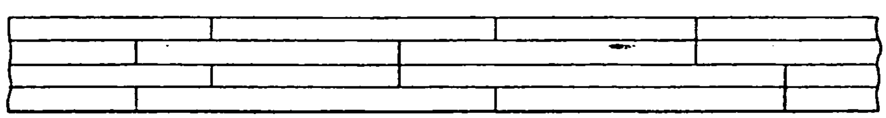

FIG. 11.

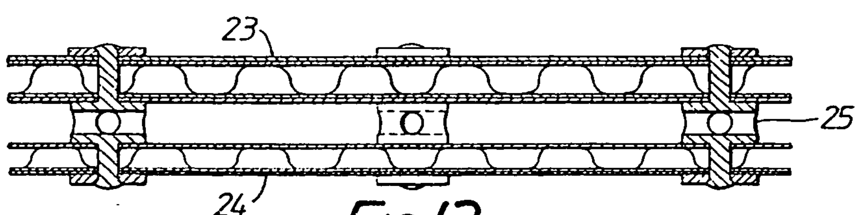

FIG. 12.

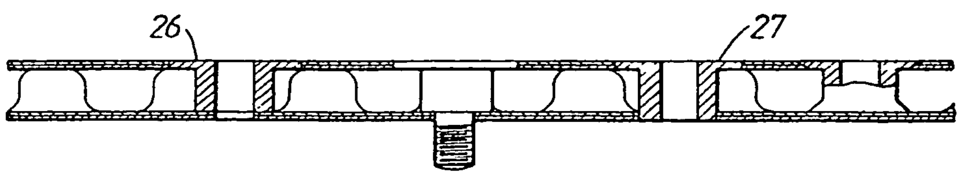

FIG. 13.

30 SEP '86 ...

2182703

4/6

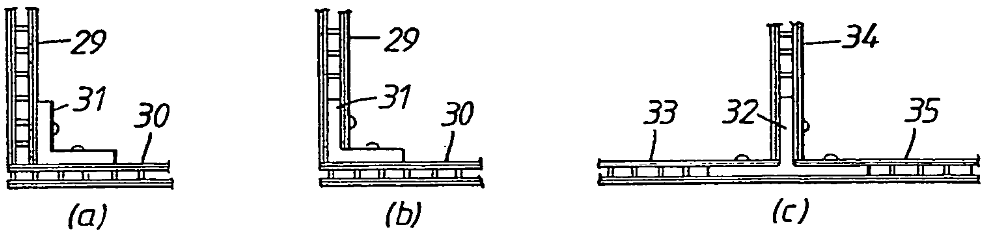

FIG. 14.

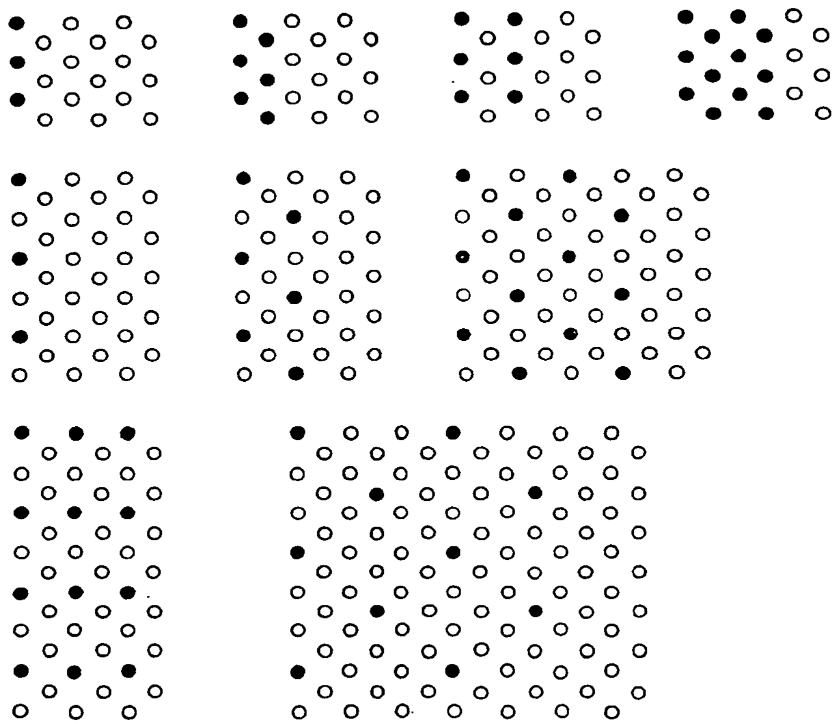

FIG. 15.

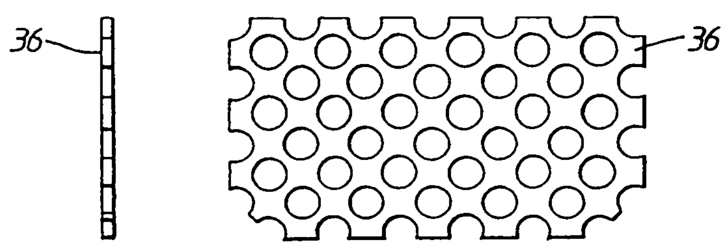

FIG. 16.

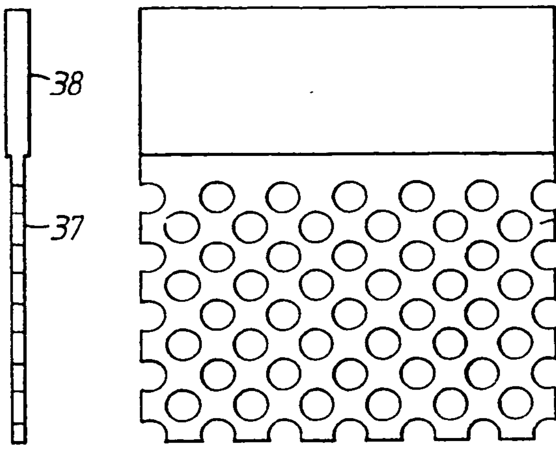

FIG. 17.

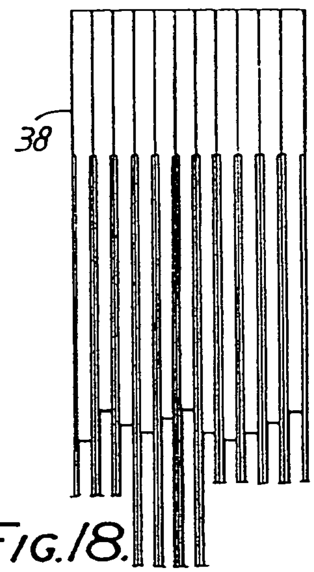

FIG. 18.

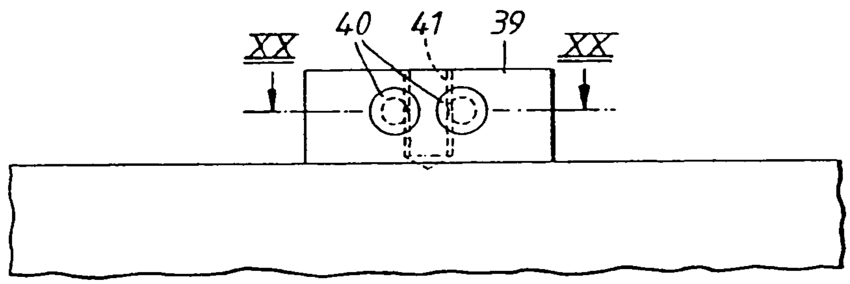

FIG. 19.

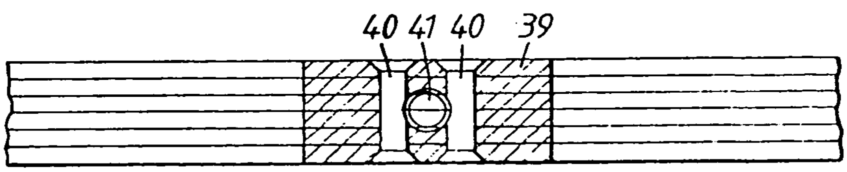

FIG. 20.

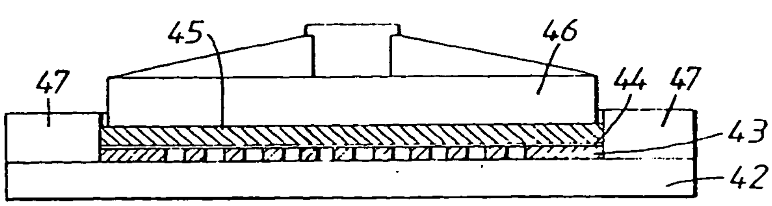

FIG. 21.

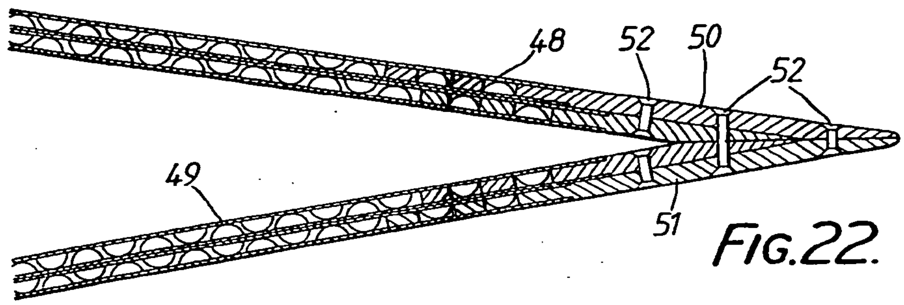

FIG.22.

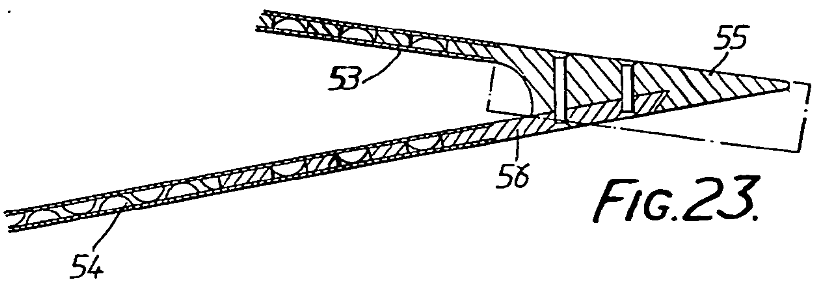

FIG.23.

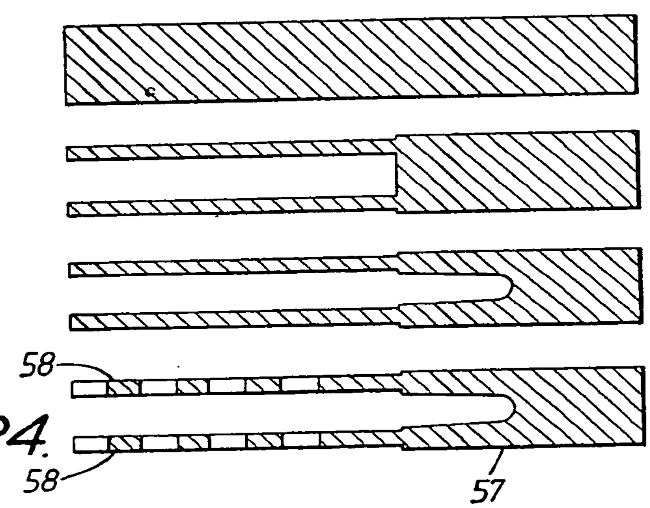

FIG.24.

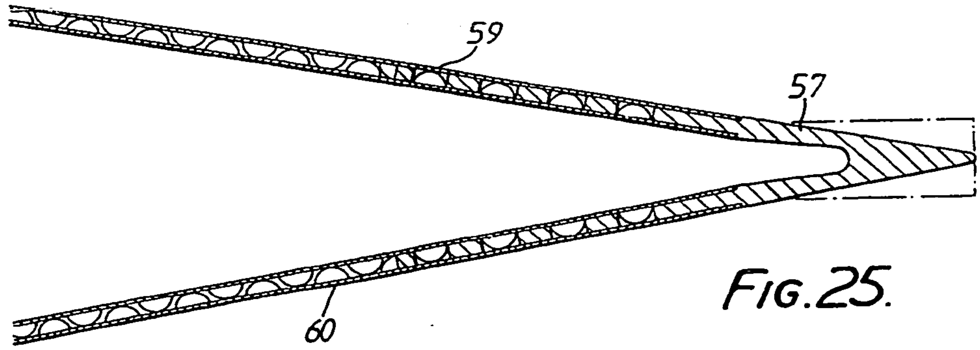

FIG.25.

SPECIFICATION

Improvements relating to structural sheet material

This invention relates to structural sheet material, and particularly to metallic plates of sandwich construction.

For a detailed analysis of the considerations taken into account, reference is made to the specifications of Application Nos. 8523996 and 8618361, from which this application claims priority.

According to the present invention there is provided a structural metallic material of plate-like form comprising two substantially smooth metal face sheets, and a core secured therebetween, the core being two metal sheets each with a plurality of discrete projections pressed therefrom and faced together with the projections interdigitating, mutual attachment of the core sheets being by bonding or welding at the peaks of the projections where they co-operate with land areas between projections of the opposite core sheet, and the face sheets being attached by bonding or welding to the opposite sides of said land areas.

The projections of each core sheet may have clearance from the surrounding projections of the opposite core sheet, or they may have contact. Conveniently the projections will be in regular rows and columns and be of uniform size.

Reinforcements additional to the core may be incorporated between the face sheets. In one form, such a reinforcement may be a plate positioned in a zone where the core sheet or sheets are projection-free. Alternatively, the reinforcement may be a plate sandwiched between core and face sheets, the latter being pressed around the plate to form a zone proud of the general plane of that face sheet.

When the projections are suitably spaced, the reinforcement can be a perforated plate, the perforations being sized and distributed to be fitted by all the projections of the area of the plate occupying core space. Such a perforated plate may be at the edge of the material and have an extension projecting beyond that edge without projection-receiving perforations. Such an extension may be thicker than the perforated portion, its surfaces being flush with the face sheet.

A perforated plate can also be used to join adjacent reinforced plates, by bridging them and interengaging with respective cores.

The material can also be built up with respective pluralities of co-planar face sheets and a plurality of cores, the sheets of one layer overlapping the junctions of sheets in the adjacent layer or layers.

Another form of reinforcement comprises plugs bonded within and filling the cavities of selected projections.

An edge finish may be provided by elongate strips bonded between edge portions of the face sheet, the core being set back from this edge, or between edge portions, being projection free, of the core sheet.

A thicker and more substantial material may be achieved by providing additional core and face sheets, similarly attached and forming a multi-ply structure with adjacent plates sharing a face sheet. The cores of the different plies may be different, and one or more of the additional ones may be single sheets with projections. The projections of one core may be offset in the plane of the mutual face sheets with respect to the projections of an adjacent core. In this case the intermediate face sheets may be omitted.

For a better understanding of the invention some embodiments will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a cross-section of part of a composite plate,

Figure 2 is a cross-section of part of two dimpled sheets forming the core of a modified plate, during construction,

Figure 3 is a diagram showing the arrangement of meshing dimples of core sheets,

Figure 4 is a section on the line IV-IV of Figure 3,

Figure 5 is a diagram showing an alternative arrangement of meshing dimples of core sheets,

Figure 6 is a section on the line VI-VI of Figure 5,

Figure 7 is a cross-section of a composite plate during assembly, with an insert,

Figure 8 is a cross-section of a composite plate, after assembly, with a differently arranged insert,

Figure 9 shows diagrams illustrating two mirror image sheets and their combination into a composite plate.

Figure 10 is a diagram showing how dimpled sheets may be located,

Figure 11 is a diagram showing how a multi-ply plate may be made up,

Figure 12 is a cross-section of a double walled plate assembly,

Figure 13 is a cross-section of a composite plate with inserts,

Figure 14 illustrates various connections between composite plates,

Figure 15 diagrammatically illustrates a selection of reinforcement patterns,

Figure 16 is a face view of a reinforcement insert,

Figure 17 is a face view of an edge reinforcement insert,

Figure 18 is a cross-section of an edge portion of a multi-ply plate, with reinforcement inserts as shown in Figure 17,

Figure 19 is a face view of an edge portion of a multi-ply plate with a connection lug,

Figure 20 is a cross-section on the line XX-

XX of Figure 19,

Figure 21 is a diagrammatic cross-section of a press for forming a dimpled core sheet,

Figure 22 is a cross-section of a V-junction between multi-ply plates,

Figure 23 is a cross-section of a V-junction between single-ply plates,

Figure 24 illustrates stages in the formation of an edge junction strip, and

Figure 25 is a cross-section of a V-junction between single-ply plates using the strip of Figure 24.

The plates to be described are all composite structures made up from thin sheet metal. It is envisaged that the widest applications will be with aluminium or its alloys, but the techniques are equally applicable to steel or other metals, and it may also be possible with plastics material, particularly those with fibre reinforcement, or a mix of metaland composite fibres. By thin sheet is meant a thickness of the order of 0.25mm although it will be appreciated that in certain circumstances thinner sheets or ones of considerably greater thickness may be used. However, at least for the sheet or sheets which make up the core of a composite plate, they must be susceptible to being transformed by a pressing operation from an initial flat stage to one having a pattern of small dimples or studs. With the thickness quoted above, it is envisaged that the dimple height will be of the order of 2.5mm, and the diameter 6-8mm, but in general the dimple height should be equal to or greater, by up to 0.075mm,than standard sheet material thickness in either metric or standard wire gauge. This is to facilitate production of inserts such as shown in Figure 16 and 17 and die plates as shown in Figure 21. Various patterns and spacings of the dimples are possible as described below.

It will be assumed throughout the rest of this specification that in each embodiment the dimples are circular stud-like formations, evenly distributed, and all of the same size. Where there are two intermeshing core sheets the dimples on one may be of a different diameter (but the same height) from those of the other, but with regular spacing they will have their centres at the same pitch. However, it is recognised that, for particular applications, a core sheet may have dimples of two or more sizes, and that they need not necessarily be arranged to a regular grid pattern. Nor is it absolutely essential that they should be circular. It will also be assumed that the finished plate is flat, although curved plates can also be produced.

Figure 1 shows a simple form of composite plate, but one which is only used as an adjunct to the invention, as a possible ply to be added to it. It consists of two face sheets 1 and 2 between which is sandwiched a single dimpled core sheet 3. The mutual attachment is by adhesive cement, such as epoxy resin, heat cured, or by welding.

Figure 2 shows part of the core of a more complex plate, comprising two dimpled sheets 4 and 5, with the dimples intermeshing. Once this core is assembled, it will be sandwiched between face sheets to make a stronger and more substantial plate than that of Figure 1.

Figures 3 and 4 show in more detail an arrangement corresponding to Figure 2, with core sheets 4 and 5 brought together with respective intermeshing sets of dimples 7 and 8. These are arranged in a rectangular grid pattern of rows and columns and they are spaced apart so that a dimple 7 of one sheet 4, such as that shown at the centre of Figure 3, fits with generous clearance within a four square set of dimples 8 of the other sheet 5. In Figure 3, the inner circle of each dimple represents its outer diameter at the mid-height while the outer circle indicates where it starts to be deformed from the base sheet. This deformation, by a pressing operation to be described later, will form each dimple with a radius at the base and at the peak, and will make it slightly frusto-conical, the half cone angle being of the order of 4-6°.

Figures 5 and 6 show a different arrangement, where the plates 9 and 10 of the core sheets have dimples 11 and 12 of somewhat larger radius so that each dimple has tangential contact at its mid-height with the four surrounding dimples. This of course makes mutual location exact and easy.

Another possibility (not shown) is to have a single sheet core with dimples pressed out to opposite sides, preferably in alternating fashion along rows and columns for even distribution.

It may be required to have solid portions or reinforcements at certain zones of the composite plate. When forming the core sheets, dimples can be omitted at opposed zones as shown in Figure 7 and the resulting space can accommodate a reinforcing plate 15 of the same thickness as the height of the dimples. This maintains the flat surfaces of the composite plate, which will be marked to show the position of any such reinforcement.

In certain circumstances, it may be required to have a reinforcement standing proud of one of the faces of the composite plate. This may be achieved as shown in Figure 8, where a double core sheet 16 is sandwiched between face sheets 17 and 18 in the manner described, but at the reinforcement zone a plate 19 is trapped between the core 16 and the face sheet 18. The latter is thin enough to deform around the bevelled periphery of the plate 19. Further reinforcing system are described later.

The edges of a plate can be finished in a manner following Figure 7. That is, the core sheets are left dimple-free along their edges, or the face sheets are extended beyond the core. A wire or strip of square or rectangular

section is laid along the edge and sandwiched between the face sheets.

The reinforced plates may be made to standard sizes as sheets or planks of various widths and subsequently cut to shape as required. However, in some cases, particularly for small structural components it may be preferred to manufacture them precisely in the first place. This is particularly so where edge fittings are to be inserted as described below. The forming of the dimples will preferably be done using a bolster, also as described in more detail later, and this enables the same apertured plate to be used for both sheets of a double core when they are asymmetrical and have to be fitted together mirror fashion as shown in Figure 9. The profiles on the left of Figures 9(a) and 9(b) indicate the core sheets, while on the right are edge views of them. The solid line profiles indicate the extent of the dimples and the broken line profiles indicate the dimple-free edge zone. When formed by the bolster method, the press will produce two dimpled mirror-image sheets with the dimples exactly opposite each other when the edges of the sheets are in registry. In order to intermesh them, therefore, one core sheet has to be shifted a half-dimple pitch in each of two orthogonal directions in relation to the other one, as indicated in Figure 9(c), before the sheets can be brought together. This leaves the edge portions out of registry, but they can be trimmed after this operation, or before.

A further problem with locating the core sheets arises with the arrangement of Figures 3 and 4 where the dimples do not contact each other as in Figures 5 and 6. It is then possible that the dimples of the respective sheets may fail to be mutually centred. A technique to ensure this is shown in Figure 10, where the rectangle 20 represents a core sheet, dimples uppermost. Guidelines 21 are stretched across this between pegs 22 so that they pass alongside and in contact with rows, columns or diagonals of dimples. The thickness of the lines 21 corresponds to the closest uniform spacing between dimples of respective sheets when they are propoerly and symmetrically mated. Thus a second core sheet located down onto the sheet 20 is forced by the lines 21 to take up the correct position, with all the dimples mutually centred. When fixing is completed, the lines can be detached from the pegs and withdrawn.

As a progression from a composite plate made up from three or four sheets as described above, thicker multi-ply plates may be similarly constructed. Each ply will consist of a pair of face sheets with a single or double dimpled sheet core sandwiched between them, but each ply will share a face sheet with the adjacent one. It is not necessary for each ply to have the same type of core. For example, in a threeply construction, the inner ply may have a core of two intermeshing dimpled sheets, while each outer ply may have a single dimpled sheet core as in Figure 1. It is also advantageous to arrange that the dimples of all the plies are not in precise registry, but that those of one are shiftedfractions of a dimple pitch with respect to those of another in the longitudinal or lateral direction, or both. With this arrangement the intermediate face plates could be omitted, and three or more core sheets could be directly stacked on one another and mutually attached.

It is not essential for a multi-ply plate to have all plies of the same dimension. For example, each ply could be less in area than the one below, giving a stepped edge, which might have a straight or curved envelope.

For applications requiring a multi-ply plate of greater area than that coverable by a single one of the size available a composite structure can be built up a diagrammatically shown in Figure 11. Each elongated rectangle represents a section or edge view of a single-ply plate, and in building up the multi-ply structure various overlapping bondings can be used as shown.

Figure 12 shows another form of multi-ply construction, where two composite plates 23 and 24 are held apart in a cavity wall arrangement by fittings 25. This arrangement reduces the thermal conductivity of the plate.

Where it is necessary to attach members to such plates, or have elements passing through them. They can be drilled in the normal way, but rather than leave raw edges of thin sheet material exposed, it is desirable, and essential in some cases, to provide reinforcement or protection at points where such apertures are made if they are not already so equipped as in Figures 7 and 8.

When the loading is light, or where it is simply a matter of protection from the edge of the aperture, inserts 26 and 27 as shown in Figure 13 can be used. These may be of metal or plastics. The insert 26 is a cylinder with a flange that fits flush within an aperture in one face of the plate, while its other end abuts the interior of the other face, in registry with a smaller aperture. The insert 27 is similar but slightly longer, and the aperture in the lower face is made larger so that the insert projects through it.

These inserts 26 and 27 are for the through passage of some element, or they could receive a screw fastener, being internally threaded or of a material in which a screw can cut its own thread. Another form of insert is shown between them, this being a stud 28, with a head whose external profile is similar to that of the insert 26 and with a threaded shank projecting from the lower face.

It will often be necessary to attach plates at angles to or edge-to-edge and flush with one another. Figure 14 illustrates certain arrangements for this. In Figure 14(a) the two plates

29 and 30 are joined by a bracket 31 butted against the inside of the corner. This is bolted or rivetted to the plates and is wholly exposed. In Figure 14(b) one flange of the bracket is concealed within the edge portion of the plate 29, which is left dimple-free for this purpose. The other flange is bolted or rivetted to the plate 30 as before. In Figure 14(c) a Tjunction is made by a correspondingly shaped insert 32, this being wholly concealed within the edge portions of the plates 33, 34 and 35. By omitting the stem of the T and the plate 34 is can be envisaged how just two plates can be connected edge-to-edge and maintain a smooth contour.

The reinforcing or solidifying arrangements of Figures 7 and 8 and the inserts of Figure 13 may be too cumbersome and inflict an unacceptable weight penalty, particularly when, for example, a large number of small rivets are to be used. A solution to this is diagrammatically illustrated in Figure 15 which shows various dimple patterns, the solid spots representing dimples which are plugged by metal inserts, contoured for a close fit and secured by epoxy resin. These reinforced dimples may have various distributions as shown in the Figure, and their positions will be indicated on the face sheets so that fastenings can be made to the correct points. Generally they will be concentrated around the edges of the plate.

Another approach, suitable for use with the single sheet core of Figure 1, or with the spaced dimples of Figures 3 and 4, is shown by Figure 16. A perforated plate 36 is sandwiched between the face sheets with the dimples projecting through the perforations. Again, its position will be marked on the face sheets, and for even further reinforcement some or all of the dimples projecting through it may be plugged as in Figure 15.

This type of reinforcement may be applied to the edge of a plate, to provide a solid edge portion. It may be extended beyond the face sheets by construting as in Figure 17, where there is a perforated section 37 and a solid section 38, with shoulders on each side between the two sections so that the section 38 has a thickness corresponding to that of the complete plate and provides a smooth continuation of it.

Another version (not shown) would have two perforated sections, possibly separated by a solid section, by which two plates could be joined edge to edge. It could be generally flat to provide a flush joint, or it could be angled to provide an alternative to Figure 14.

An alternative form of joining plates is to use a "splicing" technique. That is, when assembling the plates, the sheets of one layer are set substantially to overlap the abutting edges of the sheets of the adjacent layer or layers.

The type of reinforcement shown in Figures 16 and 17 can be used on a multi-ply plate as shown in Figure 18, where the sections 38 are in face-to-face contact, adhered together to provide a solid edge portion. The sections 37, however, are not all identical; some are longer than others so that there is a staggering of the reinforcement in from the edge. This is designed to avoid too sudden a transition and consequent stresses.

A wide variety of fittings, flush with or projecting proud of the face sheets can be built into the plates during manufacture using the insert principle of Figures 16 and 17.

This edge reinforcement can be used to provide an attachment lug 39, as shown in Figures 19 and 20, made up from a number of sections 38. In addition to the epoxy resin or other adhesive, it may be advisable to strengthen it further by rivets 40, particularly if it is to provide a tapped hole 41 extending laterally in towards the plate. These rivets 40 may be spaced so that the threading actually cuts into them.

The formation of the dimpled sheets may be carried out in various ways, including a continuous process using studded rollers. However, for small plates, and especially those which are "tailor made" to particular shapes, it will be preferable to use a press such as that diagrammatically illustrated in Figure 21. The lower platen 42 receives a perforated plate 43, the perforations corresponding to the dimple pattern to be created. The worksheet 44 is placed on top of this, and then a bolster 45. This is of tough and resilient material which is deformed from its relaxed, flat shape into the apertures of the plate 43 when pressure is applied to it by the upper platen 46, this action drawing portions of the interposed sheet 44 into those apertures and forming the dimples. The bolster is laterally confined by a rim 47 so that it does not simply spread sideways. When the pressure is relaxed, the bolster resumes it normal flat shape, and the dimpled sheet is then removed from the plate 43. If an inverse or mirror image dimpled sheet is required, as in Figure 9, the worksheet could be applied to the opposite side of the plate 43, which would be inverted, or the bolster arranged below it.

Another technique for creating the dimples is hydroforming.

Figure 22 shows the junction of two doubleply plates 48, 49 in a shallow V-formation, such as at the trailing edge of an aerofoil section. The plates are edge reinforced similarly to the arrangement of Figure 18, but the solid sections 50, 51 are bevelled at acute angles and abutted to create a V. They are secured together by rivets 52 and resin bonded if desired.

Figure 23 shows another V-junction, but between single-ply plates 53, 54. Edge reinforcements 55, 56 following Figure 17 are provided, but one of them, 55, has a solid

portion initially very much thicker than the plate 53, as indicated by the broken line. This is reduced and rebated to receive the solid portion of the other reinforcement 56 and the two are riveted and possibly bonded together.

Figure 24 shows the stages of manufacturing an alternative member for joining plates at a shallow angle, each being a cross-section of an initially plain flat bar. The final member 57 before assembly with the respective plates is of narrow U-section with the free ends of the limbs 58, perforated like the section 37 of Figure 17. These are spread to the required angle and incorporated into the edges of the plates 59, 60 as they are assembled. Finally, the base of the member 57 is reduced from the rectangular shape indicated by broken lines in Figure 25 to the sharply angled configuration.

The uses to which such plates can be put are numerous, apart from simply providing a tough lightweight skin. The hollow construction enables them to be used for the passage of liquid or gas for heating or cooling purposes, for example, and it would be possible to implant miniature electrical or electronic components and devices, and sensors for such parameters as air pressure, temperature, vibration frequency and strain.

CLAIMS

1. A structural metallic material of platelike form comprising two substantially smooth metal face sheets, and a core secured therebetween, the core being two metal sheets each with a plurality of discrete projections pressed therefrom and faced together with the projections interdigitating, mutual attachment of the core sheets being by bonding or welding at the peaks of the projections where they co-operate with land areas between projections of the opposite core sheet, and the face sheets being attached by bonding or welding to the opposite sides of said land areas.

2. A structural metallic material as claimed in Claim 1, wherein the projections of each core sheet have clearance from the surrounding projections of the opposite core sheet.

3. A structural metallic material as claimed in Claim 1, wherein the projections of each core sheet have contact with the surrounding projections of the opposite core sheet.

4. A structural metallic material as claimed in Claim 1,2 or 3, wherein the projections are in regular rows and columns.

5. A structural metallic material as claimed in any preceding claim, wherein the projections are of uniform size.

6. A structural metallic material as claimed in any preceding claim, wherein a re-inforcement additional to the core is incorporated between the face sheets.

7. A structural metallic material as claimed in Claim 6, wherein the re-inforcement is a plate positioned in a zone where the core sheet or sheets are projection-free.

8. A structural metallic material as claimed in Claim 6, wherein the re-inforcement is a plate sandwiched between the core and a face sheet, the latter being pressed around the plate which forms a zone proud of the general plane of that face sheet.

9. A structural metallic material as claimed in Claim 6, as appendent to all but Claim 3, wherein the re-inforcement is a perforated plate, the perforations being sized and distributed to be fitted by all the projections over the area of the plate occupying core space.

10. A structural metallic material as claimed in Claim 12, wherein the perforated plate is at an edge of the material and has an extension projecting beyond that edge without projection-receiving perforations.

11. A structural metallic material as claimed in Claim 10, wherein said extension is thicker than the perforated portion, having surfaces flush with the face sheets.

12. A structural metallic material as claimed in Claim 10, wherein the perforated plate bridges and interconnects adjacent plates of material by interengagement with respective cores.

13. A structural metallic material as claimed in any one of claims 1 to 11, wherein the material is built up with respective pluralities of co-planar face sheets and a plurality of cores, the sheets of one layer overlapping the junctions of sheets in the adjacent layer or layers.

14. A structural metallic material as claimed in any one of Claims 6 to 13, wherein the re-inforcement comprises, or additionally comprises, plugs bonded within and filling the concavities of selected projections.

15. A structural metallic material as claimed in any preceding claim, wherein an edge finish is provided by an elongate strip bonded or welded between edge portions of the face strips, the core being set back from this edge, or between edge portions, being projection free, of the core sheets.

16. A structural metallic material as claimed in any preceding claim, wherein there are additional cores and face sheets, similarly attached and forming a multi-ply structure with adjacent plies sharing a face sheet.

17. A structural metallic material as claimed in Claim 16, wherein at least one additional core is a single sheet with projections.

18. A structural metallic material as claimed in Claim 16 or 17, wherein the projections of one core are off-set in the plane of the mutual face sheet with respect to the projections of an adjacent core.

19. A structural metallic material as claimed in Claim 18, wherein intermediate face plates are omitted.

20. A structural metallic material substantially as hereinbefore described with reference to the accompanying drawings.

21. A modification of the structural material as claimed in any preceding claim, wherein at least one of the sheets is non-metallic or partially metallic.

22. A structural material as claimed in Claim 21, wherein at least one of the sheets is of fibre reinforced plastics material.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd, Dd 8991685, 1987.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.